AD-A067 384 NAVY UNDERWATER SOUND LAB NEW LONDON CONN F/G 17/1

A RAY TRACING PROGRAM FOR CONVERGENCE ZONES.(U)

SEP 61 L T EINSTEIN, D I LIEBERMAN, L P ONYX

UNCLASSIFIED USL-TM-921-18-61 NL

1 of 1

ADA 067384

END

DATE FILMED

6--79

DDC

THIS DOCUMENT IS BEST QUALITY PRACTICABLE.
THE COPY FURNISHED TO DDC CONTAINED A
SIGNIFICANT NUMBER OF PAGES WHICH DO NOT
REPRODUCE LEGIBLY.

LEVEL II

901.2

THIS COPY FOR: F.J. Kingsbury

COPY 34 OF 41 COPIES

(1)

AD A067384

U. S. NAVY UNDERWATER SOUND LABORATORY / USL PROBLEM
FORT TRUMBULL, NEW LONDON, CONNECTICUT 1-610-00-00

FJK 9/3/63

(6) A RAY TRACING PROGRAM FOR CONVERGENCE ZONES.

by

MOST Project-2

RETURN TO CODE 963.2 WHEN NO LONGER NEEDED

(10) L. T. Einstein, D. I. Lieberman,
L. P. Onyx [redacted] P. F. Radics, Jr.

USL Technical Memorandum No. 921-18-61

(9) (11) 28 Sep[redacted]961

DDC
RECEIVED
APR 3 1979
F

(14) USL-TM-921-18-61 (12) 11p.

INTRODUCTION

This memorandum describes a ray tracing program which has been written for the Datatron 205 to permit the computation of corrected spreading loss for convergence zone rays in a layered ocean. This program, called Ray Tracing Program VI, differs from Program II in two major respects: first, it includes a computation of the diffraction loss correction factor, α/f, needed in the vicinity of each caustic to give a finite value of spreading loss; and second, it limits printouts to those ranges at which the ray passes through the receiver depth. Rays are delineated by their values of vertex velocity, V_x, rather than vertical angles at the source, and four types of ray paths may be computed, with a variable number of range cycles between source and receiver.

alpha/f

sub x

THEORY

The subject of corrections to be used in the vicinity of caustics was introduced by Marsh in Study H of reference (a). It was shown that the complete expression for spreading loss in this case should contain a multiplicative term, $|J(\alpha)|^2$, called the first-order diffraction correction. This rather complicated correction term is a function of frequency and modifies the classical spreading loss equation, so that the intensity of a ray at a caustic remains finite, even though dR/dV_x approaches zero.

The variable in the correction factor is given by

$$\alpha = \frac{\pi f}{V_s} \cdot \frac{\left\{\frac{dR}{d(\cos\theta_0)}\right\}^3}{\left\{\frac{d^2R}{d(\cos\theta_0)^2}\right\}^2} \qquad (1)$$

650510-0132

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

Encl. 1 to USNUSL Ser 904-0196

DDC FILE COPY 921-18-61

254 200

where α = correction factor variable

R = range

θ_o = vertical angle of the ray at the source

V_s = sound velocity at the source

f = frequency in cps.

Since Program VI does not include a choice of frequency at which the correction is to be made, the output contains the correction factor α/ξ, which can then be converted to α. Figure 1 gives the corresponding value of diffraction loss in db, which, when added to the classically derived spreading loss given in the printout, yields the corrected value of spreading loss for the ray considered.

RAY TRACING PROGRAM VI

The Datatron 205 program to be described traces rays from a source depth to a receiver depth, separated by a prescribed number of deep refractions and shallow refractions or reflections, and prints information on range, travel time, spreading loss, and the diffraction loss correction factor, α/ξ.

INPUT REQUIREMENTS

1. A layered velocity-depth profile (D_n, V_n), with the depth in feet and the velocity in ft/sec. The program will handle a maximum of forty layers.

2. The depth of the source (D_s), which must correspond to a depth on the velocity-depth profile of paragraph 1.

3. The depth of the receiver (D_r), which must correspond to a depth on the velocity-depth profile of paragraph 1.

4. The vertex velocity of the ray (V_x), which determines the vertical angle at any point along the path. Several vertex velocities can be computed in the same problem by specifying the first and last rays and the increment between adjacent rays.

5. The ray is terminated after a specified number of "range cycles" (n). The first passage between D_s and D_r depends upon the "ray type" chosen (see paragraph 6), and then n complete traverses through maximum and minimum depths are added, ending at D_r.

6. There are four ray types, of which any combination can be chosen for computation, as follows:

Type 1 travels down from D_s and up to D_r – 

Type 2 travels up from D_s and up to D_r – 

Type 3 travels down from D_s and down to D_r – 

Type 4 travels up from D_s and down to D_r – 

7. Travel time (T) is an optional feature in the program, which can be included in the computations by suitable coding of the input data.

OUTPUT

The output of Program VI may be a printed list or a set of punched cards. The format of the printed output is as follows:

Line 1 -

Word 1 - Depth of source, D_s.

Word 2 - Depth of receiver, D_r.

Line 2 -

Word 1 - Vertex velocity, V_x.

Word 2 - Depth at which ray vertexes (deepest point).

Line 3 -

Word 1 - Ray type (1, 2, 3, or 4).

Line 4 -

Word 1 - 0 cycles (at this point, the ray is traced from D_s to D_r via the path specified by the ray type).

Word 2 - Horizontal range, R, in yards.

Word 3 - dR/dV_x, in yds/ft/sec. (see reference (b)).

Word 4 - $V_x \cdot d^2R/dV_x^2$, in yds/ft/sec.

Word 5 - Spreading loss in db.

Word 6 - α/ξ, the diffraction loss correction factor.

Word 7 - Travel time, T, in seconds (if desired).

Lines 5 through n -

Word 1 - The number of complete range cycles added to the above.

Words 2 through 7 - The corresponding values of R, dR/dV_x, $V_x \cdot d^2R/dV_x^2$, N_{spr}, α/ξ, and T which result from the combination of the basic ray path (Line 4) followed by the specified number of complete range cycles.

Lines 3 through n will be repeated for each ray type requested.

The format listed above is repeated from Line 2 on for each additional value of V_x requested.

The following exceptions to the above Printout are made:

1. If a requested vertex velocity is less than or equal to the velocity at the source, V_s, then V_x and V_s will be printed on Line 2 and the program will advance to the next value of V_x requested.

2. For any ray for which D_r does not fall within the upper and lower depth limits of the ray, there will be no special printout. After Line 2 is printed, the program will advance to the next value of V_x requested.

3. All rays must vertex below the source. For any ray which bounces off the bottom, the V_x and a word of all 9's will be printed on Line 2.

EXAMPLE

To test the ability of Program VI to produce acceptable results, an example was selected for which previous computations involving diffraction corrections had been made. The velocity-depth profile given in Table I of reference (c), as shown in Figure 2, was used as the input to Program VI, and the results for all four ray types in the first convergence zone were obtained for a source depth of 50 feet and a receiver depth of 100 feet. The uncorrected spreading loss for each ray type is shown in Figure 3. The diffraction corrections for a frequency of 530 cps were applied to these rays, resulting in the corrected values of spreading loss shown in Figure 4.

This figure agrees quite well with the results given in Figure 2 of reference (c). To show the effect of combining all of the available rays, assumption of random phase between arrivals was made, and Figure 5 resulted. The solid curve was derived from the data of Figure 3, and the dashed curve from the data of Figure 4. Figure 5, again, agrees satisfactorily with Figure 3 of reference (c), thus confirming the validity of the program and the correction method described.

CONCLUSIONS

Ray Tracing Program VI can be used in deriving the corrected spreading loss for rays in the vicinity of caustics. In its present form, this program suffers from the necessity to choose values of V_x in the input directions, so that it is often necessary to make two or three runs with the same velocity profile before adequate coverage of a convergence zone results. This feature would be eliminated by a computed choice of sequential values of V_x, which could be based on the desired maximum spacings of points in the output plot. An attempt will be made in the near future to derive additional program steps to give this most desirable feature.

L. T. Einstein
L. T. EINSTEIN
Physicist

D. I. Lieberman
D. I. LIEBERMAN
Student Trainee

L. P. Onyx
L. P. ONYX
Programmer

P. F. Radics, Jr.
P. F. RADICS, JR.
Electronic Engineer

LIST OF REFERENCES

(a) H. W. Marsh, Jr. and M. Schulkin, "Report on the Status of Project AMOS," USL Research Report No. 255 of 21 March 1955 (CONF).

(b) USL Memorandum Serial 1110-63 of 11 July 1960, "The Derivative Program for Ray Tracing," by D. L. Cole.

(c) M. A. Pederson and A. J. Keith, "Comparison of Experimental and Theoretical Sound Intensities for Convergence-Zone Transmission in 3100-Fathom Water," USNEL Report No. 738 of 13 December 1956 (CONF), USL Acc. No. 19434.

DISTRIBUTION LIST

Internal

USL Code 100
101
105C
900
900A
900B
905
905.1
905.2
910
911
911S
911.1
911.2
911.3
913.3
920
921
921S
921.1
921.2
923.1
930
960
961
963(5)

P. A. Barakos
D. L. Cole
M. T. Goepfert
F. J. Kingsbury
L. P. Onyx
P. F. Radics, Jr.
E. H. Scannell, Jr.
R. F. Seymour
C. E. Shippey, Jr.
W. F. Wardle
H. R. Weaver

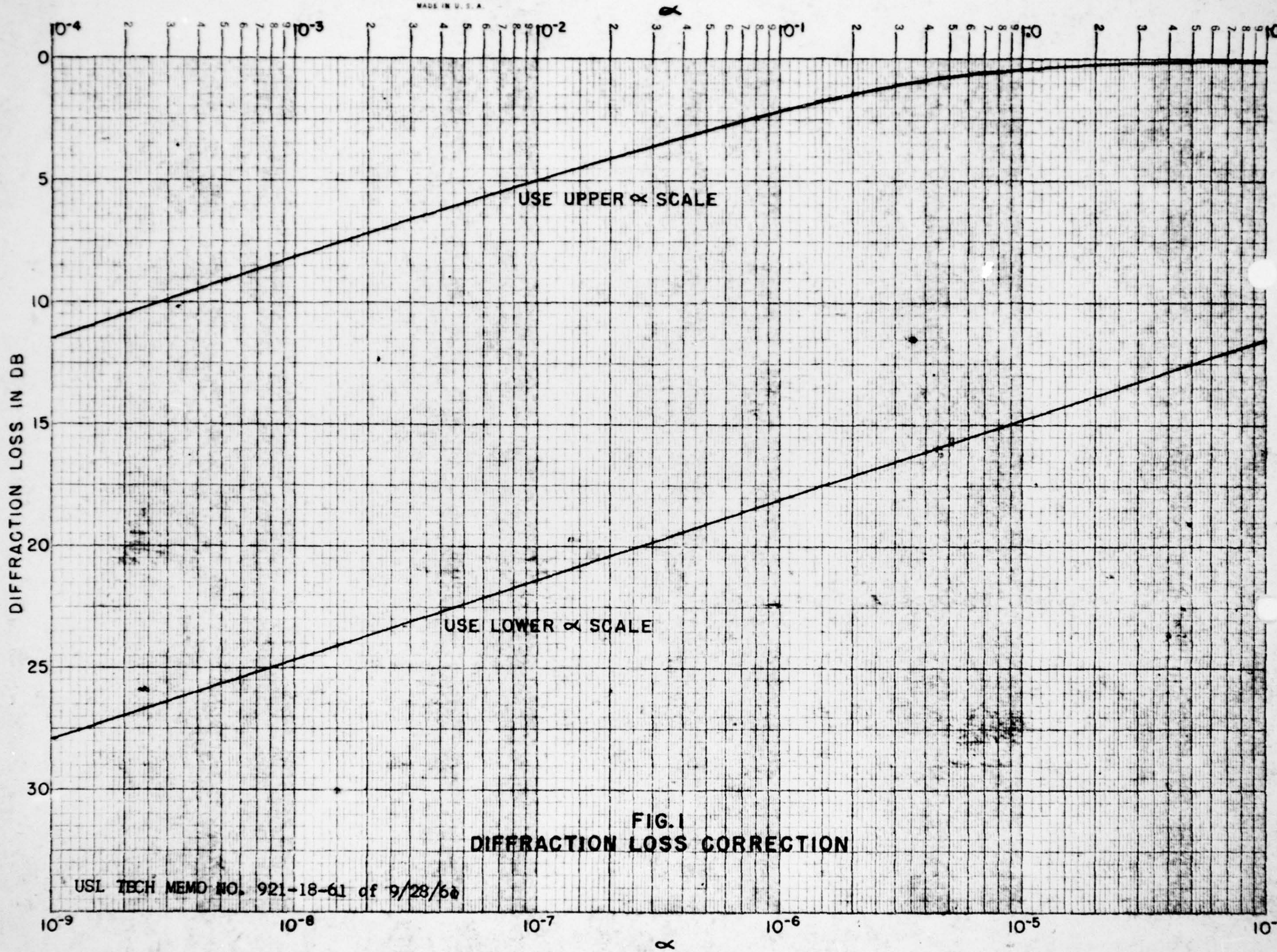


FIG. 1
DIFFRACTION LOSS CORRECTION

USL TECH MEMO NO. 921-18-61 of 9/28/61

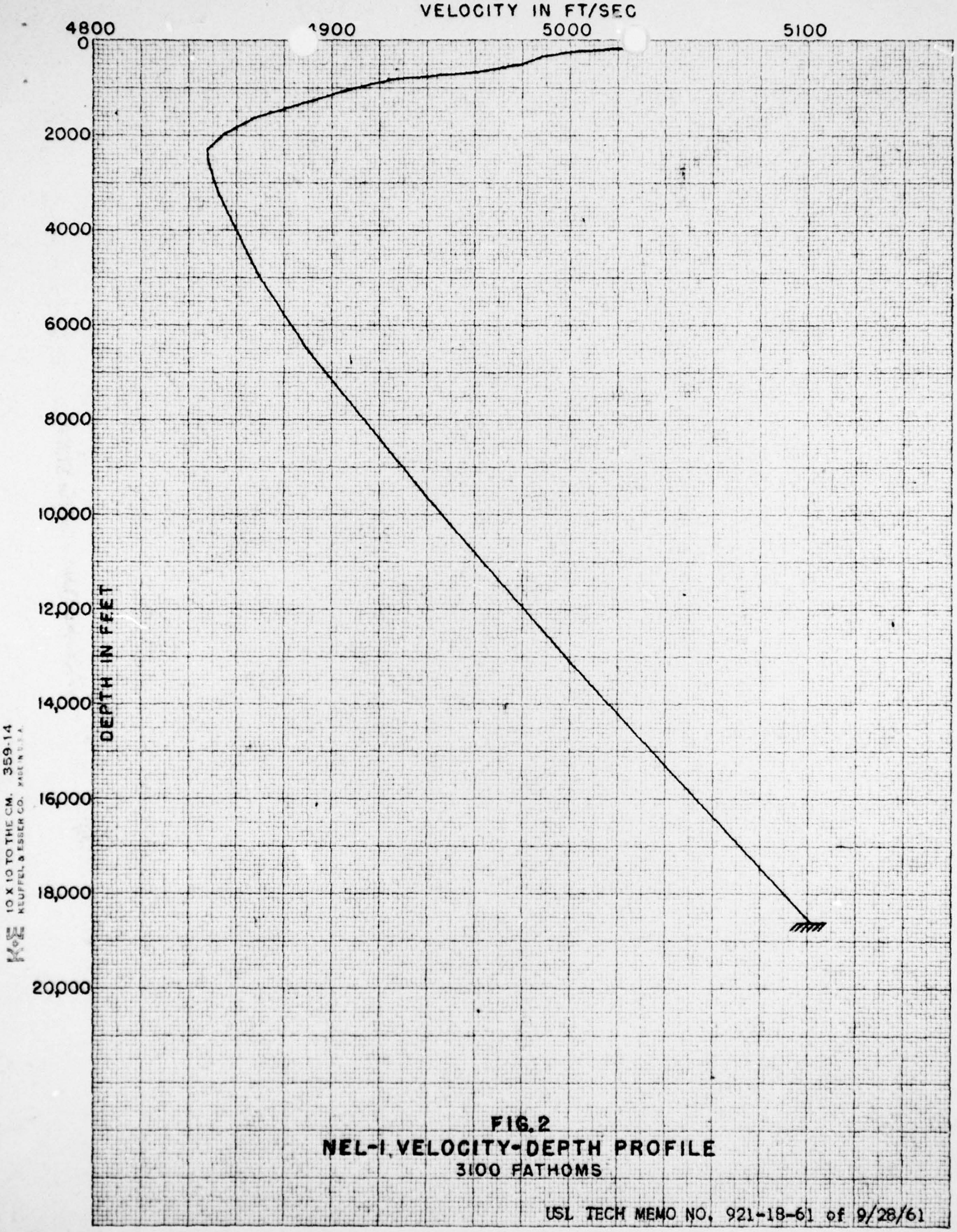


FIG. 2
NEL-1 VELOCITY-DEPTH PROFILE
3100 FATHOMS

USL TECH MEMO NO. 921-18-61 of 9/28/61

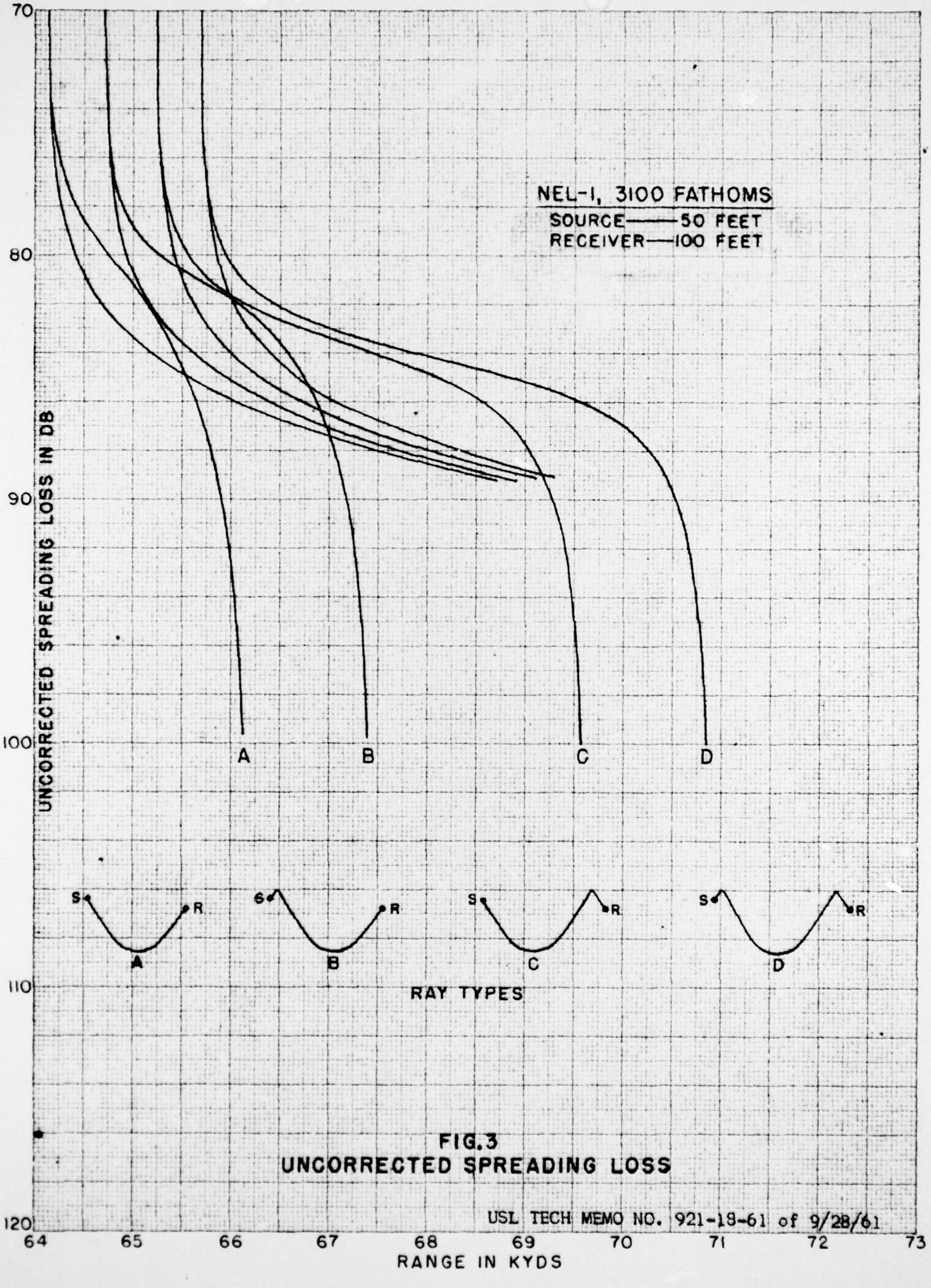
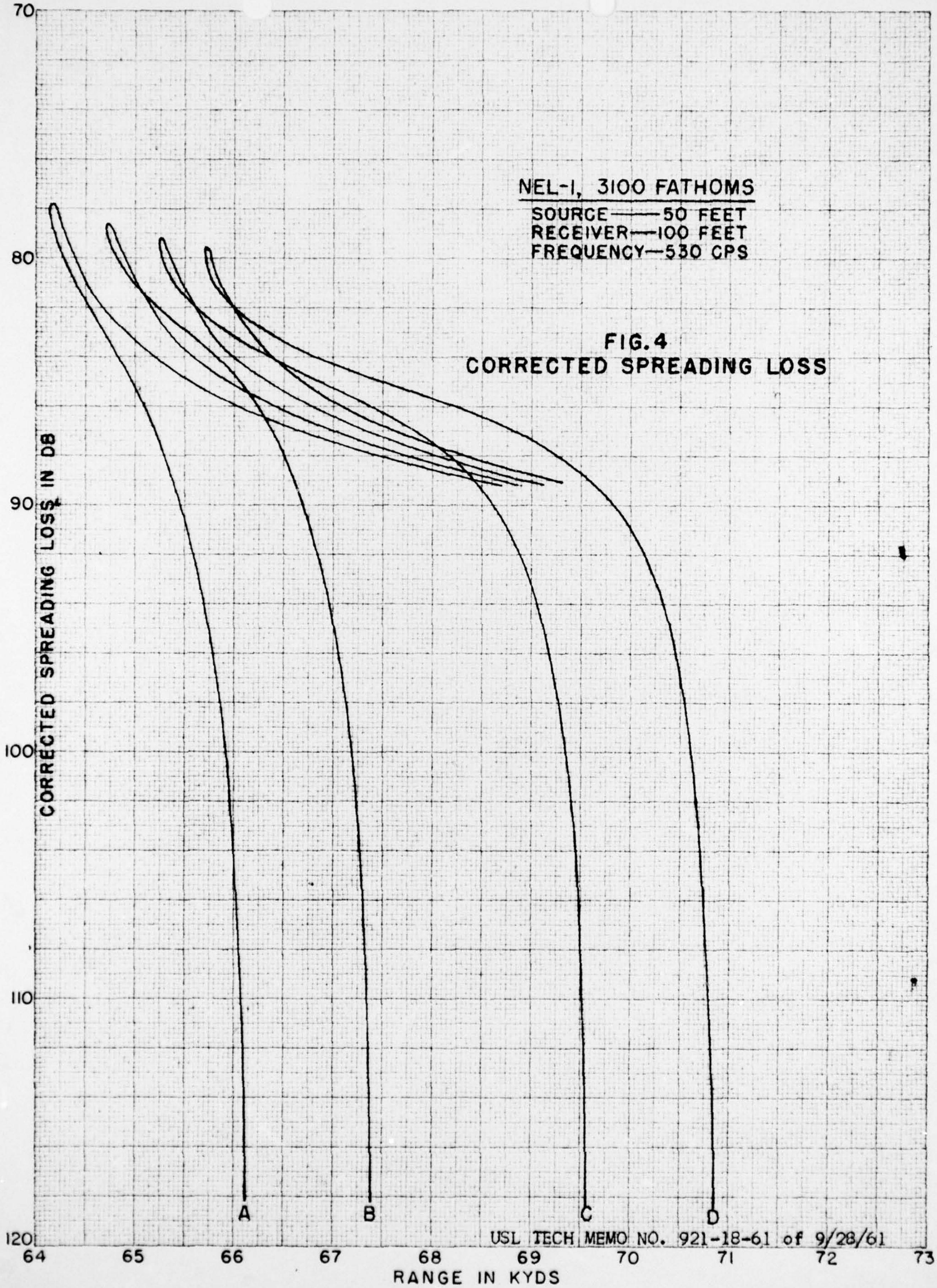


FIG.3
UNCORRECTED SPREADING LOSS

USL TECH MEMO NO. 921-18-61 of 9/28/61



USL TECH MEMO NO. 921-18-61 of 9/28/61

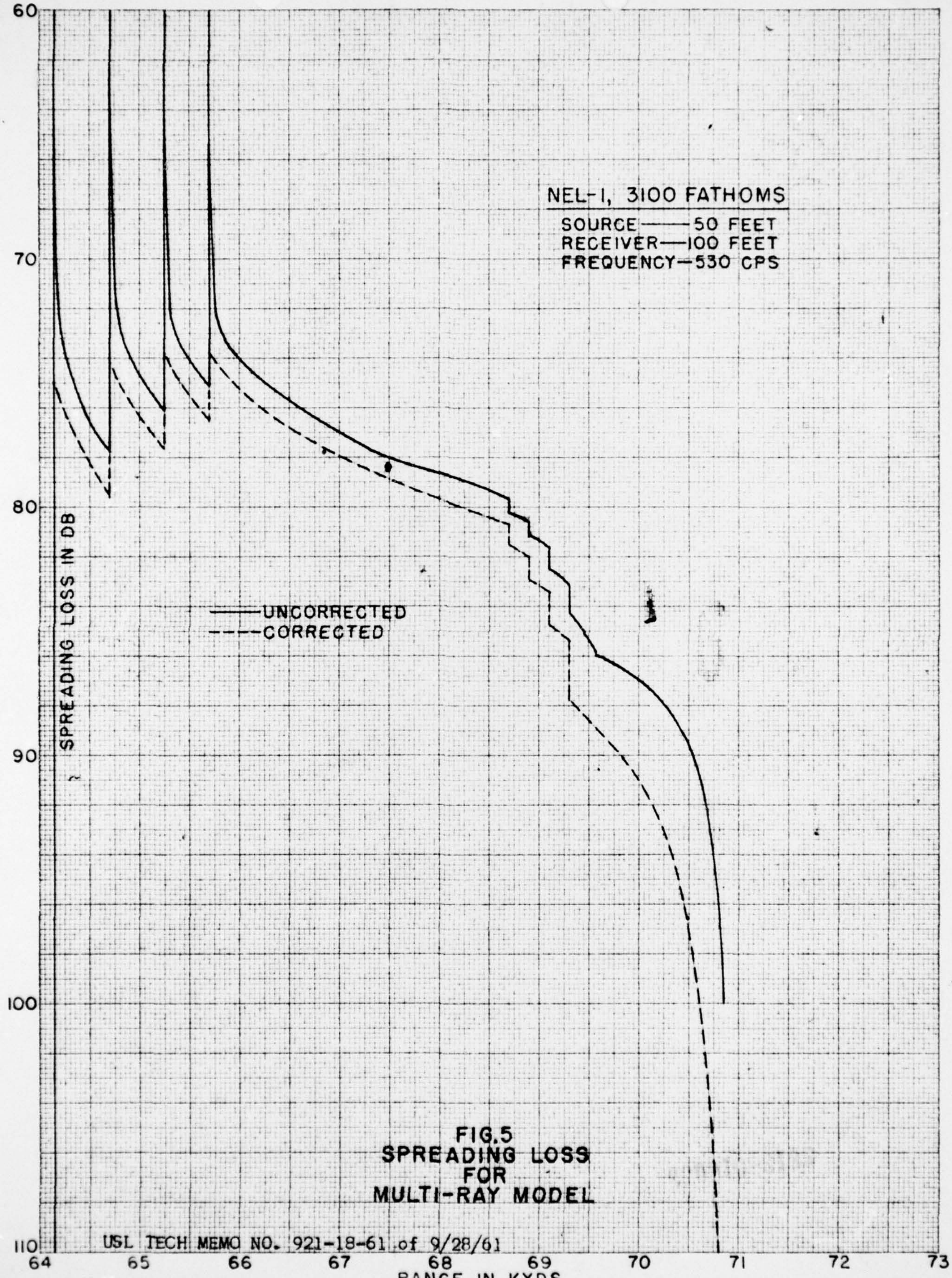


FIG.5
SPREADING LOSS
FOR
MULTI-RAY MODEL

USL TECH MEMO NO. 921-18-61 of 9/28/61